REMARKS:

Claims 1-23 are currently pending in the application. The Examiner states that Claims 1, 4-9, 12-17, and 23 lack novelty under PCT Article 33(2) as being anticipated by Jensen. The Examiner also states that Claims 1, 4, 9, 12, 17, and 23 lack novelty under PCT Article 33(2) as being anticipated by Buivid. In addition, the Examiner states that Claims 18-20 and 22 lack novelty under PCT Article 33(2) as being anticipated by Larsen. The Examiner further states that Claim 18 lacks novelty under PCT Article 33(2) as being anticipated by McArdle.

In addition, the Examiner states that Claims 2-3 and 10-11 lack an inventive step under PCT Article 33(3) as being obvious over either Jensen or Bulvid in view of Noehren et al. The Examiner also states that Claim 21 lacks an inventive step under PCT Article 33(3) as being obvious over either McArdle or Larsen in view of either Bulvid or Jensen.

Claims 5, 17, and 22 are hereby amended. Claims 1-4, 6-16, and 23 are not hereby amended. Claims 18-21 are hereby cancelled, and new Claims 24-26 are hereby added.

Claim 5 is amended to address the Examiner's objection under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6. The word "second" is inserted prior to "spring" and "damping" has been deleted, clarifying that the damper is "switched from the first spring rate to the second spring rate upon landing of the aircraft."

New dependent Claims 24 and 25 depend from Claim 22.

New independent Claim 26 is for a rotor for a rotary-wing aircraft, the rotor having a central member and a plurality of blade attachment members adapted for attaching rotor blades to the central member and allowing for lead/lag motion. The rotor also comprises "a damper having a housing and a piston movably carried within the housing, the piston having fluid passages therethrough and valve means for controlling the flow of fluid through at least one of the passages." The piston is described further as "being sealingly connected to an inner surface of the housing with deformable elements, the deformable elements allowing movement of the piston relative to the housing through elastic shearing of the deformable elements,

the deformable elements also being deformable by a force exerted by the piston on a fluid in communication with the deformable elements through bulging deformation of the deformable elements." The valve means are described as "allowing for selective switching between a first spring rate, in which elastic shearing provides a dominant spring force, and a second spring rate, in which bulging deformation provides the dominant spring force." Each damper is "operably connected to an inner end of each blade attachment member for damping the in-plane motion of the associated blade."

The present invention is directed to a soft-in-plane rotor hub for a rotary-wing aircraft, herein described using the embodiment shown as hub 31. Rotor hub 31 has a central member 33 and a plurality of blade grips 37 adapted for attaching rotor blades to central member 33. Blade grips 37 are pivotally attached to central member 33 with straps 35 and are capable of pivoting about a pivot axis generally normal to a plane of rotation of the blades, allowing for in-plane motion of the blades relative to central member 13.

Straps 35 are circumferential and are hingedly connected to central member 33 at flapping hinge 39. The inner end of each grip 37 is connected to the outer end of the associated strap 35 with a pitch horn bracket 41, and an elastomeric bearing 47 is received within a recess 49 of each bracket 41 to provide for in-plane, chordwise pivoting of brackets 41 and grips 37 about a lead/lag axis 51 passing through the focus of each bearing 47. Both elastomeric bearing 47 and flapping hinge 39 are located within strap 35, with the axes for these hinges being non-coincident. Centrifugal loads from the blades are transferred from brackets 41 into bearings 47, from bearings 47 into straps 35, then from straps 35 into central member 33. In-plane motion of a blade about the associated lead/lag axis 51 causes a proportional in-plane motion of a post 53 extending from bearing 47. Because post 53 is located inboard of axis 51, the in-plane motion of post 53 is in the direction opposite the movement of the blade.

Post 53 engages a damper 59 for damping the in-plane motion, each damper 59 being selectively switchable between at least two spring rates. Damper 59 has a piston 65 movably carried within a housing 75 and attached to inner surface 73 by 69, 71. Fluid passages 87, 89, 91, 93 are formed in piston 65 and extend from one end of

piston 65 to the other end of piston 65, allowing fluid flow between chambers 83, 85. A valve means, such as rotary valve 97, is located within primary passage 87 for selectively controlling fluid flow therethrough. When valve 97 is open, fluid flows through passage 87, providing damper 59 with a first spring rate. When valve 97 is closed, fluid is prevented from flowing through passage 87, providing damper 59 with a second spring rate that is stiffer than the first spring rate.

Seals 69, 71 are fixedly attached to inner surface 73 of housing 75 and the outer surface 77 of piston 65. Seals 69, 71 are described as preferably being formed as "sandwich" structures, with alternating layers of an elastomeric material 79 and a rigid, non-elastomeric material 81, such as a metal. The combination of the layers allows for seals 69, 71 to be nearly incompressible in a direction generally normal to the layers but also to have a limited amount of shearing motion. Fluid is always able to flow between chambers 83, 85 through passage 89. When rotary valve 97 is in the open position, fluid is allowed to flow between chambers 83, 85 through passage 87. When rotary valve 97 is in the closed position, fluid cannot flow through passage 87.

Lead/lag motion of blades causes movement of post 53 in the opposite direction, and this causes piston 65 to move relative to housing 75 and toward one of chambers 83, 85. When rotary valve 97 is open, movement of piston 65 is resisted by the shear force required to deform seals 69, 71, providing a spring rate, k_{shear}, for damper 59, and the restricted fluid flow through passages 87, 89, acts to damp oscillations of piston 65. This is shown in Figure 6. When rotary valve 97 is closed, the movement is resisted by the force required to bulgingly deform seals 71, as shown in Figure 7. Because fluid is restricted to flowing through only secondary passage 89, the fluid pressure caused by piston 65 causes the central portion of seals 69, 71 to bulge outward. The force required provides a spring rate, k_{bulge}, for damper 59, k_{bulge}, being a higher value than k_{shear}. The flow restriction to fluid flowing through passage 89 damps oscillations of piston 65.

With regard to Claims 1, 4-9, 12-17, and 23, the Examiner states that Jensen '533 discloses all claimed parts. Jensen discloses a rotary-wing aircraft having blades pivotally connected to a rotor hub, allowing for movement of the blades in the plane of motion. This lead/lag motion is controlled by a switchable damper having a piston 108

within a cylindrical element 106, the piston having a restricted passage 146 therethrough for allowing fluid to pass between chambers 110, 112. Piston 108 also has spring-biased relief valves 148 and 150 for relieving excessive pressure. In addition, the damper has a bypass conduit 152 for connecting chambers 110, 112. A solenoid valve 154 is located in conduit 152, valve 154 being electrically switchable between two damping rates by movement of a valve member 160 between open and closed positions. Valve member 160 is spring biased toward the closed position, in which the damper has a high damping rate, and is opened when solenoid valve 154 is energized, providing a lower damping rate. Valve 154 is operatively connected by electrical circuits to the landing gear of the aircraft, such that solenoid valve 154 is energized when the aircraft becomes airborne and the pilot retracts the gear.

In the disclosed system, Jensen does not teach or show the use of deformable elements to provide the damper with a spring rate. The Jensen damper is a pure fluid damper, which resists motion only with the restricted flow of incompressible fluid through 146, 152. The Jensen damper provides only a damping rate.

On the other hand, the claimed invention comprises a system for damping lead/lag motion, in which deformable seals 69, 71 provide damper 59 with a spring rate and the restricted fluid flow through passages 87, 89 provide damper 59 with a damping rate. Moving rotary valve 97 between the open and closed positions allows for selection between a spring rate and associated damping rate and a second, stiffer set of spring and damping rates.

Independent Claim 1 of the present application is an apparatus claim that requires a central member, a plurality of blade attachment members pivotally attached to the central member and allowing for in-plane motion of the blades relative to the central member, and "a damper operably connected to each blade attachment member for damping the in-plane motion of the associated blade, each damper being selectively switchable between at least first and second spring rates." Jensen does not show or teach the use of a damper having a spring rate and does not show or teach the use of a damper being selectively switchable between at least two spring rates.

Independent Claim 9 of the present application is directed to a soft in-plane proprotor assembly for a tiltrotor aircraft, the assembly comprising a central member, a plurality of proprotor blades, a plurality of blade attachment members pivotally attached to the central member and allowing in-plane motion of the blades relative to the central member, and "a damper operably connected to each blade attachment member for damping the in-plane motion of the associated blade, each damper being selectively switchable between at least first and second spring rates." As discussed above for Claim 1, Jensen does not show or teach the use of a damper having a spring rate and does not show or teach the use of a damper being selectively switchable between at least two spring rates.

As amended in the present submission, independent Claim 17 of the present application covers a rotor hub assembly for a rotary-wing aircraft having a central member and a plurality of blade attachment members for attaching rotor blades to the central member, the blade attachment members allowing for lead/lag in-plane motion of the blades relative to the central member. The claim also requires a damper connected to an inner end of each blade attachment member for damping the in-plane motion. Each damper is described as "having valve means for controlling the flow of fluid within the damper to allow the damper to be selectively switchable between at least two spring rates and a damping rate associated with each spring rate." As discussed above, Jensen does not show or teach the use of a damper having a spring rate and does not show or teach the use of a damper being selectively switchable between at least two spring rates and associated damping rates.

Independent Claim 23 of the present application is a method claim for damping in-plane motion of blades of an aircraft rotor. The method requires pivotally attaching blade attachment members to a central member, attaching a rotor blade to each blade attachment member, operably connecting each blade attachment member to a damper selectively switchable between at least two spring rates, and switching each damper to achieve a selected in-plane stiffness. Jensen does not show or teach a method of damping in-plane motion of rotor blades using a damper having a spring rate and does not show or teach a method using a damper being selectively switchable between at least two spring rates.

For the foregoing reasons, the Applicants respectfully submit that independent Claims 1, 9, 17, and 23, and their associated dependent claims, are not anticipated by Jensen and do not lack novelty under PCT Article 33(2). Therefore, the Applicants respectfully request that the Examiner issue an International Preliminary Examination Report indicating that Claims 1, 4-9, 12-17, and 23 are novel under PCT Article 33(2).

With regard to Claims 1, 4, 9, 12, 17, and 23, the Examiner states that Bulvid discloses all claimed parts. Bulvid discloses a damper 30 for use in damping in-plane motion of rotor blades 22. Each damper 30 comprises a housing 50, a piston 52 movably carried within housing 50, and a control valve 36. One of housing 50 and piston 52 are operably connected to a pivotable blade, and the other of housing 50 and piston 52 is connected to non-movable portion of the rotor hub. As piston 50 and housing 52 move relative to each other, fluid is moved between chambers 60, 62 through pipes 64 and control valve 36. Control valve 36 comprises a housing 66 having a through passage 68, and restriction plugs 72 are located in either end of passage 68. Bypass valves have spring-biased balls 78 that engage seats 80. In addition, a port 70 connects passage 68 to a remote fluid reservoir 38. Orifices in restriction plugs 72 provide damper 30 with a selected nominal damping rate. However, overpressure within passage 68 causes balls 78 to lift from seats 80, allowing fluid to bypass restriction pugs 72. During assembly, selected springs are installed to achieve the desired overpressure requirement necessary to unseat balls 78.

In the disclosed system, Bulvid does not teach or show the use of a damper having a spring rate as well as a damping rate. Also, Bulvid does not teach or show a damper that is selectively switchable between spring rates. Damper 30 is a fluid damper having only a damping rate and no spring force. Damper 30 does employ a passive type of bypass that is not actively controlled, but this bypass only changes the damping rate of damper 30.

As described above, the claimed invention comprises deformable seals 69, 71, which provide damper 59 with a spring rate while restricted fluid flow through passages 87, 89 provides damper 59 with a damping rate. Damper 59 is selectively switchable between a spring rate and associated damping rate and a second, stiffer set of spring and damping rates.

As stated above, each of Independent apparatus Claims 1, 9, and 17 and Independent method Claim 23 of the present application requires a damper selectively switchable between at least two spring rates. As this is not shown in the Bulvid reference, the Applicants respectfully submit that independent Claims 1, 9, 17, and 23, and their associated dependent claims, are not anticipated by Bulvid and do not lack novelty under PCT Article 33(2).

With regard to Claims 18-20 and 22, the Examiner states that Larsen discloses all claimed parts. Claims 18-20 have been cancelled, and Claim 22 has been amended. Larsen discloses an aircraft rotor having members 14 that act to attach blades to a central hub. A pivot pin 13 passes through an inboard end of each member 14 to provide for a flapping hinge. The outer end of each member 14 is "forked in a vertical plane" (col. 2, lines 28-29), creating a pair of prongs 17 that engage prongs 18 at the inboard, root end fitting 19 of each blade. "The two pairs of forks are apertured in their interengaging portions to receive a pivot 20" (col. 2, lines 32-34), which forms a lead/lag pivot for in-plane motion.

In the disclosed system, Larsen does not teach the use of a blade strap that encircles the flapping hinge and a bearing of the associated lead/lag hinge. Rather, members 14 are shown and described as having forked outer ends, a pivot 20 extending through apertures formed in each forked end.

On the other hand, the claimed invention comprises a unitary, loop-type blade strap 35 (19 in the embodiment of Figure 1) that encircles both flapping hinge 39 and elastomeric lead/lag bearing 47.

Independent Claim 22 of the present application is an apparatus claim for a proprotor assembly for a tiltrotor aircraft, the assembly having a central member, a plurality of blade attachment members, and a plurality of blades. The assembly has a flapping hinge connecting each blade attachment member to the central member and a lead/lag hinge connecting each blade to a blade attachment member, the axes of the hinges or each blade being non-coincident. The claim also requires a blade strap that encircles each flapping hinge and a bearing of the associated lead/lag hinge. Claim 22 is herein amended to clarify that each blade strap is a "unitary loop."

As amended, Claim 22 requires a blade strap that is a unitary loop, and this is not shown in the Larsen reference. Therefore, the Applicants respectfully submit that independent Claim 22 and new dependent Claims 24 and 25 are not anticipated by Larsen and do not lack novelty under PCT Article 33(2).

With regard to Claim 18, the Examiner states that McArdle discloses all claimed parts. Independent Claim 18 and dependent Claims 19-21 are cancelled.

With regard to dependent Claims 2-3 and 10-11, the Examiner states that Jensen and Bulvid disclose all claimed parts of independent Claims 1 and 9, except for the use of elastomeric bearings where the pivot axis of each blade attachment member passes through a focus of the associated bearing. The Examiner relies upon Noehren et al. to supply the feature of elastomeric bearings. The Examiner states that Noehren et al. teaches a close formation aircraft system that includes preprogrammed commanded data for maintaining a formation. The Examiner also states that it would have been obvious to one skilled in the art at the time the invention was made to include preprogrammed commanded data into the control system of Constant prior to flight.

However, as has been discussed above with respect to Claims 1 and 9 above, neither Jensen nor Bulvid teach the use of a damper having spring rates in addition to a damping rate or of a damper being selectively switchable between spring rates. There is also no suggestion in Noehren et al. to have a damper having spring rates or a damper selectively switchable between spring rates. Therefore, the combination of either Jensen or Bulvid and Noehren et al. would not produce a rotor hub as in the claimed invention. Thus, the claimed invention would not have been obvious to one skilled in the art at the time the invention was made.

For the foregoing reasons, the Applicants submit that Claims 1 and 9 are not obvious over either Jensen or Bulvid in view of Noehren et al., and that Claims 2-3 and 10-11 do not lack an inventive step under PCT Article 33(3).

The Examiner states that dependent Claim 21 lacks an inventive step under PCT Article 33(3) as being obvious over either McArdle or Larsen in view of either Bulvid or Jensen. Claims 18-21 have been cancelled.

It should also be noted that the system of the claimed invention provides a switchable valve means located within piston 65 of damper 59. Primary passage 87 extends through piston 65, and rotary valve 97 is located within passage 87, eliminating the need for an external conduit and valve for controlling fluid flow through the switchable passage

Therefore, Claim 26 has been added, and this claim requires a damper having a housing and a piston movably carried within the housing, the piston having fluid passages therethrough and valve means for controlling the flow of fluid through at least one of the passages. Jensen does not teach or show that movable valve member 160 may be located within piston 108 of the damper. The Jensen disclosure shows and describes only a system in which solenoid valve 154 is located in an external conduit 152 that connects chambers 110, 112.

The Applicants submit that the foregoing comments point out for the Examiner the distinctions between the rejected independent claims of the present application and the cited prior art. Because the independent claims are allowable, additional dependent Claims 2-8, 10-16, 24 and 25 are also allowable.

The Applicants respectfully request that the Examiner find that Claims 1-17 and 22-26 meet the requirements of PCT Articles 33(2)-(4) and issue an International Preliminary Examination Report to that effect.

No fees are deemed to be necessary; however, the undersigned hereby authorizes the Commissioner to charge any fees that may be required, or credit any overpayments, to **Deposit Account No. 502806**.

Respectfully submitted,

12/22/05

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AGENTS FOR APPLICANTS

To control the chordwise motion of blades about the lead/lag axis, a damper 29 is installed in each strap 19 and is operably connected to the associated blade grip 21. Dampers 29 are each preferably selectively switchable between at least two spring rates, allowing for hub 11 to be readily configured to have selected in-plane stiffness values. The advantage of selectable in-plane stiffness is that hub 11 can be made stiff enough to prevent ground-resonance conditions when the aircraft is resting on a surface, yet hub 11 can be made softer during flight for minimizing loads and fatigue on components of hub 11 and other components of the aircraft. Dampers 29 are preferably switched through electric actuation, though other types of actuation may alternatively be used, and the switching of dampers 29 is preferably automatically controlled by aircraft control systems. For example, the aircraft control systems may switch dampers 29 to a stiffer setting upon a signal that the aircraft is within a selected proximity of the ground or upon a signal generated by sensors indicating contact of the landing gear with the ground.

Figures 2 through 4 show a simplified, three-blade alternative embodiment of a rotor hub of the invention. Figure 2 is an exploded view, Figure 3 is a partial cutaway of the assembly, and Figure 4 is a cross-sectional plan view of the assembly. Referring to these figures, hub 31 includes central member 33, blade straps 35, and blade grips 37. Central member 33 is adapted to fixedly receive mast 34. Straps 35 are circumferential and are hingedly connected to central member 33 at flapping hinge 39. This allows for out-of-plane flapping motion of blades (not shown) attached to blade grips 37. Each blade grip 37 receives the root end of a blade in the outer end of grip 37, and the inner end of each grip 37 is connected to the outer end of the associated strap 35 with pitch horn brackets 41. Each grip 37 can rotate about an associated pitch axis 43, and the pitch for the blades is controlled using pitch horns 45 on brackets 41. An elastomeric bearing 47 is received within a recess 49 of each bracket 41 to provide for in-plane, chordwise pivoting of brackets 41 and grips 37 about a lead/lag axis 51 passing through the focus of each bearing 47. Both elastomeric bearing 47 and flapping hinge 39 are located within strap 35, with the axes for these hinges being non-coincident. This

configuration allow for better packaging of the components of hub 31, especially in tiltrotor applications.

Claims

1. **(Original)** A proprotor hub for a tiltrotor aircraft, the hub comprising:

a central member;

a plurality of blade attachment members adapted for attaching proprotor blades to the central member, the blade attachment members being pivotally attached to the central member for pivoting about a pivot axis generally normal to a plane of rotation of the blades, the pivoting allowing for in-plane motion of the blades relative to the central member; and

a damper operably connected to each blade attachment member for damping the in-plane motion of the associated blade, each damper being selectively switchable between at least first and second spring rates.

2. **(Original)** The hub according to claim 1, further comprising:

a bearing operably connecting each blade attachment member to the central member;

wherein the pivot axis of each blade attachment member passes through a focus of the associated bearing.

3. **(Original)** The hub according to claim 2, wherein the bearing is an elastomeric bearing.

4. **(Original)** The hub according to claim 1, further comprising:

at least one pin pivotally connecting each blade attachment member to the central member;

wherein the pivot axis of each blade is coaxial with the associated at least one pin.

5. **(Amended)** The hub according to claim 1, wherein each damper is selectively switched from the first spring rate to the second spring rate upon landing of the aircraft.

6. **(Original)** The hub according to claim 5, wherein the second spring rate is stiffer than the first spring rate.

7. **(Original)** The hub according to claim 1, wherein each damper is selectively switched from the second spring rate to the first spring rate upon takeoff of the aircraft.

8. **(Original)** The hub according to claim 7, wherein the first spring rate is softer than the second spring rate.

9. **(Original)** A soft in-plane proprotor assembly for a tiltrotor aircraft, the assembly comprising:

a central member;

a plurality of proprotor blades;

a plurality of blade attachment members, each member attaching one of the blades to the central member, the blade attachment members being pivotally attached to the central member and capable of pivoting about a pivot axis generally normal to a plane of rotation of the blades, the pivoting allowing for in-plane motion of the blades relative to the central member; and

a damper operably connected to each blade attachment member for damping the in-plane motion of the associated blade, each damper being selectively switchable between at least first and second spring rates.

10. **(Original)** The proprotor assembly according to claim 9, further comprising:

a bearing operably connecting each blade attachment member to the central member;

wherein the pivot axis of each blade attachment member passes through a focus of the associated bearing.

11. **(Original)** The proprotor assembly according to claim 10, wherein the bearing is an elastomeric bearing.

12. **(Original)** The proprotor assembly according to claim 9, further comprising:

at least one pin pivotally connecting each blade attachment member to the central member;

wherein the pivot axis of each blade is coaxial with the associated at least one pin.

13. **(Original)** The proprotor assembly according to claim 9, wherein each damper is selectively switched from the first spring rate to the second spring rate upon landing of the aircraft.

14. **(Original)** The proprotor assembly according to claim 13, wherein the second spring rate is stiffer than the first spring rate.

15. **(Original)** The proprotor assembly according to claim 9, wherein each damper is selectively switched from the second spring rate to the first spring rate upon takeoff of the aircraft.

16. **(Original)** The proprotor assembly according to claim 15, wherein the first spring rate is softer than the second spring rate.

17. **(Amended)** A rotor hub assembly for a rotary-wing aircraft, comprising:

a central member;

a plurality of blade attachment members adapted for attaching rotor blades to the central member, the blade attachment members being pivotally attached to the central member and capable of pivoting about a pivot axis generally normal to a plane of rotation of the blades, the pivoting allowing for in-plane motion of the blades relative to the central member; and

a damper operably connected to an inner end of each blade attachment member for damping the in-plane motion of the associated blade, each damper having valve means for controlling the flow of fluid within the damper to allow the damper to be selectively switchable between at least two spring rates and a damping rate associated with each spring rate.

18. **(Cancelled)**

19. **(Cancelled)**

20. **(Cancelled)**

21. **(Cancelled)**

22. **(Amended)** A proprotor assembly for a tiltrotor aircraft, the assembly comprising:

a central member;

a plurality of blade attachment members;

a plurality of blades;

a flapping hinge connecting an inner portion of each blade attachment member to the central member, each flapping hinge having an axis generally parallel to a plane of rotation of the assembly and providing for out-of plane motion of the corresponding blade attachment member;

a lead/lag hinge connecting each blade to the blade attachment member, each lead/lag hinge having an axis generally normal to the plane of rotation of the assembly and providing for in-plane motion of the blade relative to the blade attachment member, the axes being non-coincident; and

a blade strap that encircles each flapping hinge and a bearing of the associated lead/lag hinge, each blade strap being a unitary loop.

23. **(Original)** A method for damping in-plane motion of blades of an aircraft rotor, the method comprising the steps of:

attaching blade attachment members to a central member, the blade attachment members being pivotable about an axis generally normal to a plane of rotation of the central member;

attaching a rotor blade to each blade attachment member, each blade being capable of in-plane movement relative to the central member;

operably connecting each blade attachment member to a damper for damping in-plane motion of the associated blade, each damper being selectively switchable between at least two spring rates;

switching each damper to achieve a selected in-plane stiffness.

24. **(New)** The proprotor assembly according to claim 22, wherein the blade strap is oriented to extend out of the plane of rotation of the assembly.

25. **(New)** The proprotor assembly according to claim 22, further comprising:

a damper operably connected to each blade attachment member for damping the in-plane motion of the associated blade, each damper being selectively switchable between at least first and second spring rates.

26. **(New)** A rotor for a rotary-wing aircraft, the rotor assembly comprising:

a central member;

a plurality of blade attachment members adapted for attaching rotor blades to the central member, the blade attachment members being pivotally attached to the central member and capable of pivoting about a pivot axis generally normal to a plane of rotation of the blades, the pivoting allowing for in-plane motion of the blades relative to the central member; and

a damper having a housing and a piston movably carried within the housing, the piston having fluid passages therethrough and valve means for controlling the flow of fluid through at least one of the passages, the piston being sealingly connected to an inner surface of the housing with deformable elements, the

deformable elements allowing movement of the piston relative to the housing through elastic shearing of the deformable elements, the deformable elements also being deformable by a force exerted by the piston on a fluid in communication with the deformable elements through bulging deformation of the deformable elements, the valve means allowing for selective switching between a first spring rate, in which elastic shearing provides a dominant spring force, and a second spring rate, in which bulging deformation provides the dominant spring force;

wherein each damper is operably connected to an inner end of each blade attachment member for damping the in-plane motion of the associated blade.